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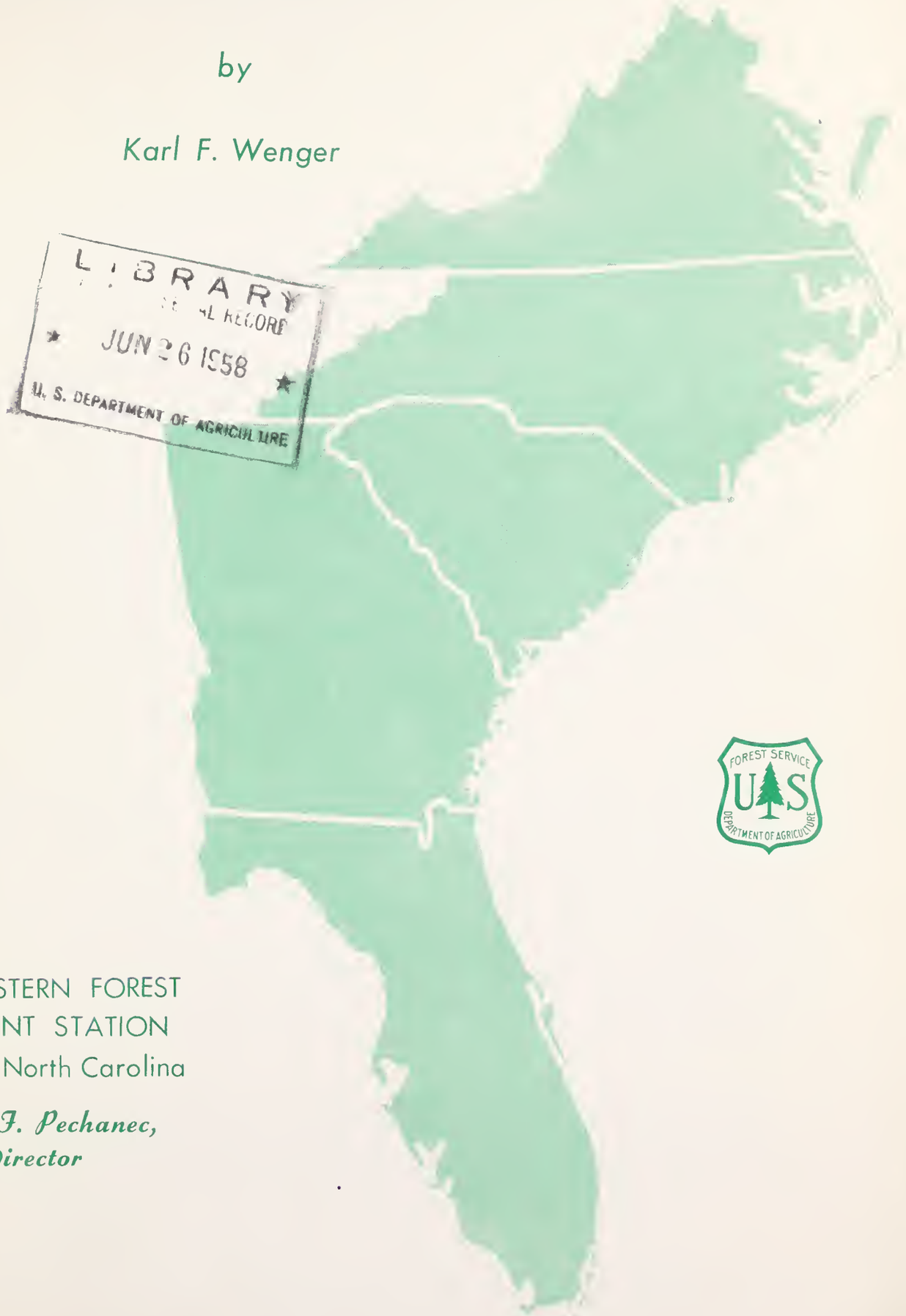

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

Silvical Characteristics of Pond Pine

(Pinus serotina Michx.)

by
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Pond pine (Pinus serotina Michx.) is found in the Coastal Plain from southeastern Virginia south to central and southeastern Alabama, and on Cape May, New Jersey (fig. 1) (11). It occurs more frequently in poorly drained flats than on drier uplands, and is the characteristic tree of the extensive evergreen-shrub bogs, commonly called "pocosins," in eastern North Carolina.

HABITAT CONDITIONS

CLIMATIC

The climate of the pond pine range is mild and humid. The frost-free season ranges from 190 days in the north to 347 days in the south (19). Rainfall averages 45 to 55 inches annually, but exceeds 60 inches in western Florida. It is heavier in the summer, nearly twice as much rain falling from June to August as in any other 3-month period. Average maximum temperatures are 90° to 100° F. and average minimum temperatures are 10° to 20° F. Temperatures of -10° in the north and 110° F. in the south have been recorded.

PHYSIOGRAPHIC AND EDAPHIC

The lower Coastal Plain is very flat and characterized by swamps, marshes, and poorly developed drainage patterns. In North Carolina the interstream areas are very broad and poor drainage has resulted in development of extensive beds of peat and organic soils (21). These areas are true upland bogs, with streams draining them on all sides. For that reason they were given the name "pocosin," or "swamp-on-a-hill," by the Indians, and are so called to this day. Here the largest acreages of pure pond pine stands occur. Farther south, shallow, poorly drained depressions, called bays or ponds, frequently support stands of pond pine. On better drained soils, pure stands are not common, and the species is usually found as an associate in other forest types.

Although pure stands occur most frequently on soils of high organic matter content, the species grows best on mineral soils.[1/] Height growth is slower as the organic matter content of the soil increases. Peat beds are the poorest sites for pond pine and the site index becomes lower as the depth of the peat increases.

1/ Hoffman, J. G. The effect of certain soil characteristics on the height growth and site index of pond pine in the Coastal Plain of the Carolinas, Georgia and Florida. 1949. (Doctorate dissertation, Duke University.)

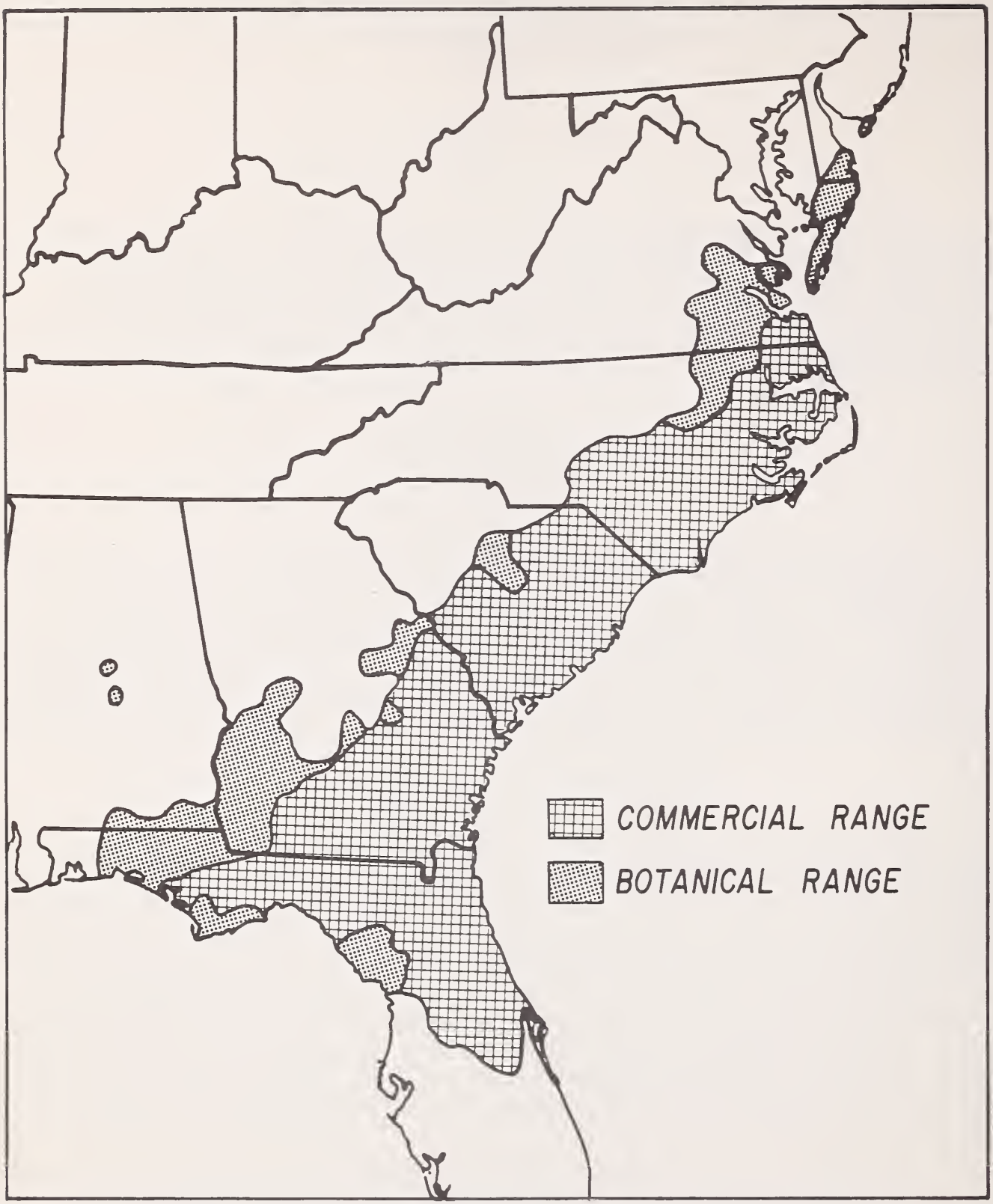

Figure 1.--The botanical and commercial range of pond pine.

The slower growth on organic soils results mainly from prolonged water saturation, which prevents soil aeration.[2/] Poor aeration retards decay of organic material and causes high soil acidity. Although availability of mineral nutrients is usually adequate, nitrogen fixation and nitrification proceed very slowly. Consequently, the amount of available nitrogen is small, even though total nitrogen content is high in the undecayed organic matter. Soil saturation also deprives roots of the oxygen required for respiration and growth and tends to keep soil temperature low.

BIOTIC

Minor associates in pure stands of pond pine are loblolly pine (Pinus taeda), baldcypress (Taxodium distichum), sweetgum (Liquidambar styraciflua), sweetbay (Magnolia virginiana), loblolly-bay (Gordonia lasianthus), redbay (Persea borbonia), and swamp tupelo (Nyssa sylvatica var. biflora) (16). In the pocosins, or evergreen-shrub bogs, trees are usually rather scattered and a great variety of evergreen shrubs form a dense understory (21). Common shrubs are gallberry (Ilex glabra), tall inkberry (Ilex coriacea), zenobia (Zenobia cassinefolia), swamp ironwood (Cyrilla racemiflora), wax-myrtle (Myrica cerifera), bayberry (Myrica caroliniensis), and saw palmetto (Serenoa repens). Laurel greenbrier (Smilax laurifolia) is almost always present and switch cane (Arundinaria tecta) is locally abundant.

On moist or wet sites, pond pine is the chief associate in the cabbage palmetto-slash pine type, the Atlantic white-cedar type, and the pondcypress type (16). It is also frequently found in the loblolly pine, slash pine, slash pine-hardwood, slash pine-swamp tupelo, and sweetbay-swamp tupelo-red maple types on poorly drained sites.

While no animal can be said to be directly associated with pond pine, the black bear (Euarctos americanus) is fairly common in the extensive pocosins where pond pine is the characteristic tree. With the exception of several large swamps, the black bear is practically nonexistent in other parts of the Coastal Plain. Other animals native to the region are also found more or less abundantly in pond pine areas.

LIFE HISTORY OF THE SPECIES

SEEDING HABITS

Flowering and Fruiting

Flower buds are formed some time during the summer, and flowers bloom late the following March in Florida and about a month later in North

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2/ Auten, J. T. Soil site reconnaissance of Dare County, North Carolina. West Virginia Pulp and Paper Co., N. C. Woodlands Res.--Westvaco Expt. Forest Rpt. NO-1. 1955. (Cited by permission of the West Virginia Pulp and Paper Co.)

Carolina (2). Pond pine normally flowers considerably later than loblolly or slash pine in the same latitude, but the flowering period may overlap that of loblolly pine in some years.

Cones require two growing seasons to mature. They ripen early in September in eastern North Carolina (6) and probably a few weeks earlier in the southern part of the range.

Seed Production and Dissemination

Pond pine begins to produce cones at an early age. In a pocosin area in eastern North Carolina, 4- to 10-year-old trees produced a total of 8 cones per tree over a 3-year period (6). Cone production increased rapidly up to 40 years of age, then remained constant. At less than 40 years of age, cone production was directly related to both age and diameter. At greater ages, it was directly related only to diameter.

In the same study, the percentage of defective cones was strongly related to tree age, ranging from 8 percent on trees less than 10 years old up to 61 percent on trees over 60 years old. Most of the loss was probably caused by a small moth, Dioryctria amatella. Trees older than 30 years bore an average of 170 sound cones.

The cones of pond pine are serotinous and few open to release seed the same autumn they ripen. Consequently, cones of several ages are normally present on cone-bearing trees (fig. 2). They open gradually over several

Figure 2.--Closed, sound cones of several ages on one branch.

years. Scarcely any closed, sound cones older than 5 years were found in eastern North Carolina (6), but frequent fire may have caused many cones to open early. Cones open more readily on some trees than on others. Open cones may persist 10 years or longer on the trees. The cones open rapidly following surface fires or felling of the trees. In bright sunlight on summer days, cones begin to open a few minutes after the tree is felled, but in the shade or during the cooler hours, or in winter, they open more slowly (6).

The total number of seeds per cone averaged 79 and was found to be directly related to length of the cone, but did not vary significantly with age or size of the tree. In the study in eastern North Carolina, 23 percent of the seeds were not released during extraction treatment, suggesting that all seeds are not released when the cones open on the tree. The viability of extractable seed averaged 48 percent and varied significantly among individual trees and tree ages. Viability did not vary with the length of time sound cones remained on the trees, however. Seed from 3-year-old cones germinated as well as seed from 1-year-old cones.

The intense heat and partial burning to which cones are subjected during fire apparently do not seriously reduce the viability of the contained seed. Fifty-nine percent of seed from cones that were badly charred during a fire in eastern North Carolina germinated within 30 days after planting, while seed from slightly charred cones was 57 percent viable.[3/]

Pond pine seed is wind-disseminated. It is smaller than loblolly pine seed, averaging 54,000 per pound (20). Consequently, it probably is distributed at least as far from the source as loblolly pine seed. However, because the cones open gradually over a period of several years, no specific period of seedfall exists. Seedfall probably occurs at any season of the year if the weather is warm and dry. In eastern North Carolina, appreciable quantities of seed began to fall in April and continued to fall until November, but the viability was only 30 percent, in comparison with 60 percent for seed falling immediately after a fire.[4/]

VEGETATIVE REPRODUCTION

Unlike most other pines, pond pine sprouts readily to advanced ages. Seedlings sprout prolifically, and stands up to sapling size are re-established by sprouting after light fires. Older trees also sprout and put forth many sprouts along stems and branches after defoliation by fire or other agencies (fig. 3).

3/ Ernst, William, Jr. Official correspondence, Southeastern Forest Experiment Station, Asheville, N. C. March 12, 1957. (Used by permission of the West Virginia Pulp and Paper Company.)

4/ Crutchfield, D. M. Official correspondence, Southeastern Forest Experiment Station, Asheville, N. C. December 10, 1957. (Used by permission of the West Virginia Pulp and Paper Company.)

Figure 3.--Pond pine on land of West Virginia Pulp and Paper Company, Dare County, North Carolina. Above, stem and branch sprouts after severe fire. Left, stem sprouts on fire-defoliated tree.

Sprouts arise from dormant buds that are formed in the axils of primary needles of young seedlings (17, 18). The buds remain alive and are protected by bark and the characteristic crook at the base of most seedlings, but they do not sprout unless the seedling is injured. These buds may give rise to secondary buds, forming clusters of dormant buds embedded in the bark just above the root collar.

In addition, not all buds formed at intermediate and winter nodes sprout the following spring. Those that do not sprout remain alive, sometimes developing into short, weak branches and so give rise to many lateral buds. They may also put forth secondary dormant buds directly without growing into branches. Buds may also form in needle fascicles but these are of little importance in the sprouting of pond pine because they are present only a short time (12). Thus, pond pine stems and branches bear many clusters of dormant buds that remain alive and capable of sprouting for many years. When trees are defoliated by fire, these buds sprout and give the stems and branches a feathery appearance. Stem sprouting is one of the primary reasons for the low quality of pond pine in frequently burned areas.

SEEDLING DEVELOPMENT

Establishment

Although specific data on the seedbed requirements of pond pine are not available, exposed mineral soil is probably the best seedbed. However, adequate moisture for germination evidently is also present in peat and organic soils because of the high water table, and pond pine seed germinates readily on exposed surfaces. Thus, in two different locations in eastern North Carolina, very few seedlings were established in the absence of fire, but satisfactory numbers appeared following burning (15).[5/]

The number of seedlings established varied with intensity of burning. After a head fire, 58,200 seedlings per acre were found, compared with 25,500 after a flank fire. This difference was due to better seedbed conditions created by the headfire rather than to seed supply. In another area 2,250 seedlings per acre became established after an intense wildfire, but only one-sixth as many followed a comparatively light fire. Seed supply apparently was an important factor in this case.

In one burned area, seedling numbers decreased with increasing depth to water table. Four times as many seedlings followed burning in brush as in switch cane areas, but seedling numbers did not vary significantly with brush density. Because brush and switch cane areas were in different locations, factors other than cover type may have influenced seedling establishment.

5/ Besse, J. D. Initial influence of fire on the regeneration of pond pine. 1952. (Master's thesis, School of Forestry, North Carolina State College.)

Other activities that expose mineral soil, such as logging or grazing, have been ineffective in promoting seedling establishment. These failures were apparently due to lack of seed, since logging and grazing do not hasten opening of the cones on trees of the seed source. In Dare County, North Carolina, exploratory trials of prescribed burning for site preparation resulted in satisfactory stocking of seedlings, but comparatively few seedlings were established where site preparation consisted only of disturbance incidental to logging, or of disking, brush cutting, or fire plow furrowing after logging.6/

The favorable seedbed conditions created by burning deteriorate in a few years. In one test, 1,700 seedlings per acre were established in the first growing season after burning and 500 per acre in the second. Some of this difference was probably due to seed supply, since most seed is probably cast soon after the fire.

The mortality of seedlings is greatest in their first year and declines in subsequent years. In a pocosin area in eastern North Carolina, seedling mortality was as follows (15):

Seedling height class (Inches)	Mortality per year (Percent)
1-6	30
7-12	19
13-24	11
25-72	3

In a similar area, 20 to 25 percent of seedlings in brush died during the second year.7/ In switchcane, seedling mortality varied with the intensity of the preceding fire; 38 percent died where a headfire had burned, and 17 percent died where the burning had been by a flank fire.

Because pond pine cones do not open readily unless heated, natural regeneration is extremely slow and very uncertain in the absence of fire. A properly timed and executed fire will bring down a large quantity of seed and prepare the seedbed at the same time. Burning may be done either before or after the harvest cut, but a prelogging fire will result in the fall of a larger amount of seed and will also improve logging conditions. However, satisfactory techniques for prescribed burning in pocosin areas have not yet been developed. Because organic soils will burn when dry, burning should be done only when the water level is near the surface of the ground, but with such conditions the vegetation often will not burn. On the other hand, when the vegetation is dry enough to carry the fire, the rate and intensity of burning may be so great that the fire gets out of control.

6/ See footnote 4.

7/ See footnote 3.

Lopping and scattering cone-bearing slash after mechanical scarification of the seedbed may also be effective, but saturated organic soils often will not support heavy equipment.

Seed trees will be needed if fire follows logging and probably should also be left when fire precedes logging. Trees 9 to 10 inches d.b.h. and larger and 30 years or more in age can be expected to produce at least 5,000 sound seed each (6). Thus, at least 6 trees per acre are needed for the satisfactory seeding of a prepared seedbed.

Early Growth

On mineral soils the beginning of shoot growth in spring probably occurs at about the same time that it does in loblolly pine. On organic soils, it is closely related to the drop in the water table that occurs when temperature rises and transpiration increases (15). However, organic soils hold large amounts of water and warm up slowly, so that growth of pond pine begins later than on mineral soils (9).

In a study of pond pine seedling growth in a pocosin area in eastern North Carolina (15), seedlings grew more in height in their first year than in any of the next 2 or 3 years. These seedlings also grew more in years of lesser rainfall, probably because the water level dropped earlier and the growing season was therefore longer. The data indicated that the average seedling would become 5 feet tall in about 18 years and the fastest growing seedlings would reach that height in less than 10 years. Another group of seedlings became 5 feet tall in 8 to 10 years (4). Growth rates of pond pine seedlings from 1943 to 1946 in a peat area were as follows (15):

Height class (Inches)	Average annual growth (Inches)	Maximum annual growth (Inches)
1-6	1.9	13.0
7-12	1.5	9.1
13-24	3.3	17.0
25-36	4.8	15.2
37-48	6.8	18.0
49-60	8.0	17.2

Although pond pine characteristically grows in poorly drained areas, pond pine seedlings suffered more than loblolly pine seedlings from prolonged flooding of the root system in greenhouse experiments. One test showed that 3 months of continuous flooding permanently injured the roots of pond pine, but loblolly pine was permanently injured only by flooding for 10 months (5). Another test showed that pond pine seedlings could endure

flooding only two-thirds as long as loblolly pine. 8/ The deep root systems and wind-firmness of pond pine trees in the presence of high water tables suggests that older trees may be able to tolerate flooding better than seedlings.

The photosynthetic rate of pond pine is undoubtedly lower than that of associated hardwoods. The needles are arranged just as in loblolly pine, in which the lower photosynthetic rate is caused by mutual shading of the needles (10). Consequently, pond pine seedlings are at a disadvantage in competition with hardwoods and will probably respond to release in the same way as other southern pines (8). In eastern North Carolina, pond pine seedlings grew slightly faster in a grazed area, probably because grazing reduced competition (15).

The Nantucket pine moth (Rhyacionia frustrana) is regularly found attacking pond pine seedlings and small trees. On poor sites, attacks by this insect may seriously reduce height growth. Other insects which may occasionally cause serious losses are the pales weevil (Hylobius pales), sawflies (Neodiprion spp.), and the pine webworm (Tetralopha robustella).

SAPLING STAGE TO MATURITY

Growth and Yield

The height growth of pond pine is faster on soils of heavier texture and good internal drainage, indicated by greater depth to mottling. 9/ Pond pine also grows faster in the southern part of the range, where the growing season is longer. In pond pine areas, surface soil contains varying percentages of organic matter, and height growth is slower where the organic matter content is higher and the organic layer deeper.

Pond pine normally does not grow to large size in pocosins and its growth is retarded by frequent fires. Average sizes attained in a pocosin in North Carolina were as follows (7):

Age (Years)	Height (Feet)	D.b.h. (Inches)
20	28	5.8
50	49	10.4
100	66	13.8

8/ Gaiser, R. N. The growth of loblolly and pond pine seedlings under differing conditions of soil flooding. 1947. (Unpublished manuscript, Dept. of Botany, Duke University.)

9/ See footnote 1.

On sites of better quality, which occur on mineral soils and the margins of pocosin areas, growth rates are considerably higher. On beds of deep peat, growth is very slow.

Stands in pocosins have rather low volumes, seldom over 5,000 board-feet per acre. The trees are often of poor form and quality. Although well-stocked stands may be found on poor sites, stand density generally increases with site quality,[10] and on favorable sites where fires are infrequent, stands of greater volume and of good vigor and form occur. Site quality in pocosins can often be substantially improved by drainage, which also improves logging conditions.

Yields of pond pine stands at 55 years range from 6 standard cords per acre on 40-foot sites to 45 cords per acre on 90-foot sites.[11]

Pond pine is subject to the fusiform rust (Cronartium fusiform) and the round gall rust (Cronartium cerebrum), both of which cause stem and branch lesions and have alternate stages on oak. Several rusts (Coleosporium spp.) attack the foliage but have little effect. Pond pine needles are sometimes severely browned by Hypoderma lethale and by the brown-spot fungus (Scirrhia acicola), but severe damage is rare. Red-heart (Fomes pini) is common in some stands, especially on poor sites, and may greatly reduce their value.

Pond pine is also subject to attack by the southern pine beetle (Dendroctonus frontalis), the black turpentine beetle (Dendroctonus terebrans) and the engraver beetles (Ips spp.).

Reaction to Competition

Although the tolerance of pond pine has not been judged, it should probably be considered an intolerant tree, of about the same degree of tolerance as loblolly pine, less tolerant than slash, and more tolerant than longleaf. Thus, pond pine should respond to thinning in much the same way as other intolerant species.

On mineral soils, pond pine is a transient stage in the secondary succession. It becomes established in pure, even-aged stands usually after fire. Hardwoods develop as an understory and become dominant when the pine stand disintegrates (14).

In the pocosins, pond pine follows Atlantic white-cedar where the cedar is killed by fire; however, if the fire is light and the first in a long time, cedar becomes reestablished (3). Because of its sprouting ability, pond pine

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10/ Schumacher, F. X., and Coile, T. S. Yield of pond pine in standard cords for the 50 to 60 year age class. 1949. (Unpublished manuscript, School of Forestry, Duke University.)

11/ See footnote 10.

survives wet-season fires, even when severely defoliated, but severe dry-season fires eliminate it, leaving a stand of sprout hardwoods. Repeated fires on poorly drained mineral soil eventually result in a grass-sedge bog, or "savannah." Frequent burning in evergreen-shrub bog eventually produces an Aristida-Vaccinium community.

SPECIAL FEATURES

Data on the oleoresin constitution of pond pine are incomplete, but a trial analysis gave the following results (13):

Density	0.8478^{20}
Index of refraction	1.4734^{20}
Specific rotation, degrees	-105.5
Turpentine yield, percent	about 20
Chemical composition of turpentine, percent	80-90 limonene

RACES AND HYBRIDS

Since pond pine has been studied very little, no recorded information exists regarding geographic races or other kinds of genetic variation. However, experienced observers believe that a natural hybrid of pond pine and loblolly pine occurs where these species are closely associated.[12/] These two species have been artificially cross-pollinated and the progeny are growing at the Westvaco Experimental Forest, near Georgetown, South Carolina (1).

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